Virtual Airspace Simulation Technologies (VAST)
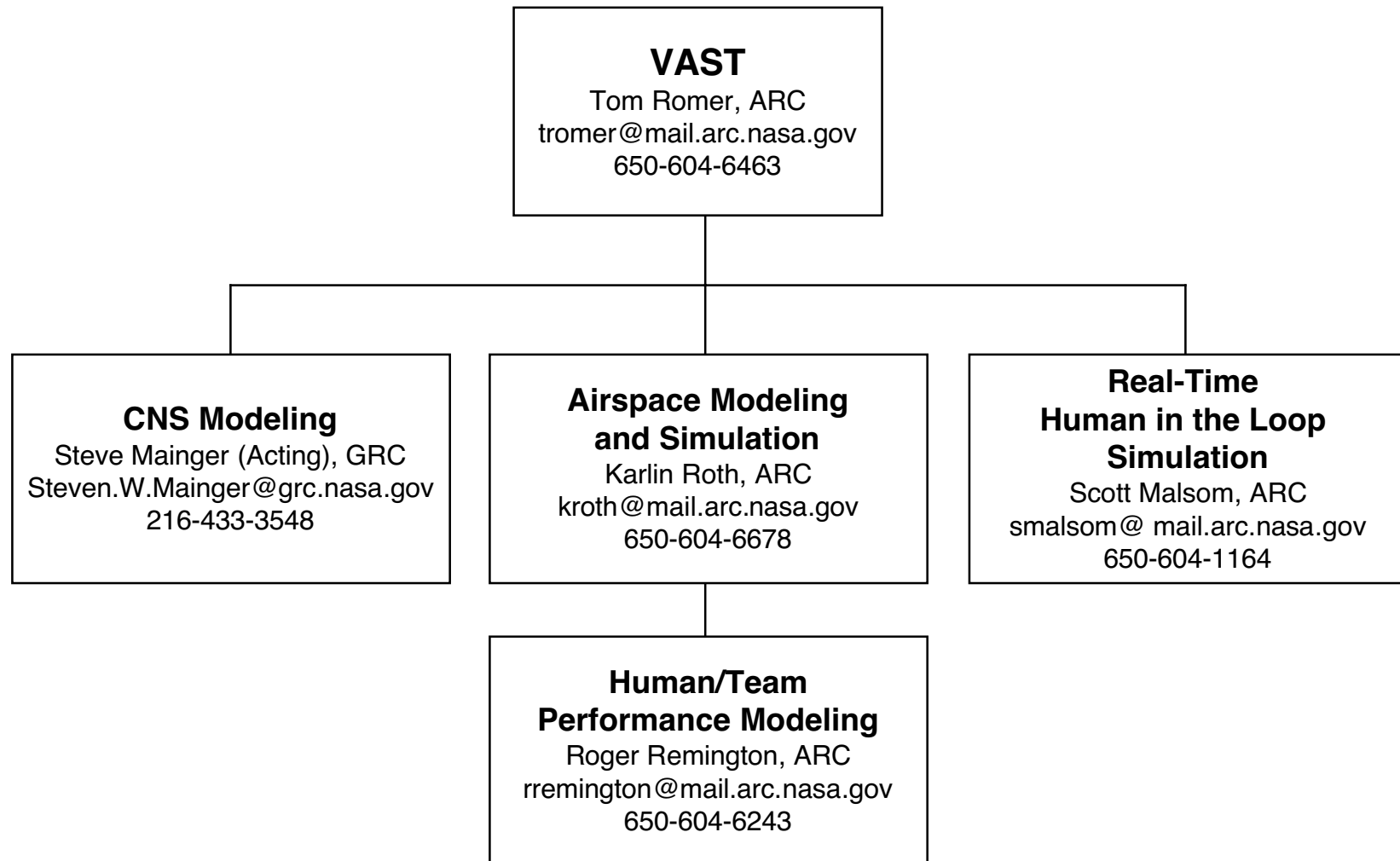
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May 21, 2002

Outline

- **VAST Description**

- **VAST Development Approach**

- **VAST Interdependencies**

- **VAST Challenges**

- **Summary**

VAST Description

- **VAST provides a validated virtual airspace simulation environment with modeling and simulation capabilities to assess the integrated behavior of current and future air transportation system concepts and technologies at the system-wide level and at the detailed human-in-the-loop level**

- **Airspace Concept Evaluation System**
  - Interoperable models representing the actions and highly coupled interactions of the air transportation system's key components
  - Non-real-time environment capable of assessing the impact of new technologies, procedures and concepts of operation on the safety, capacity, economics and security of the nation's air transportation system

- **Human-In-The-Loop Simulation**
  - Distributed network simulation capability that integrates real-time software models, human interfaces and simulation labs and facilities
  - Real-time simulation environment that adequately addresses human interactions with air transportation system technologies
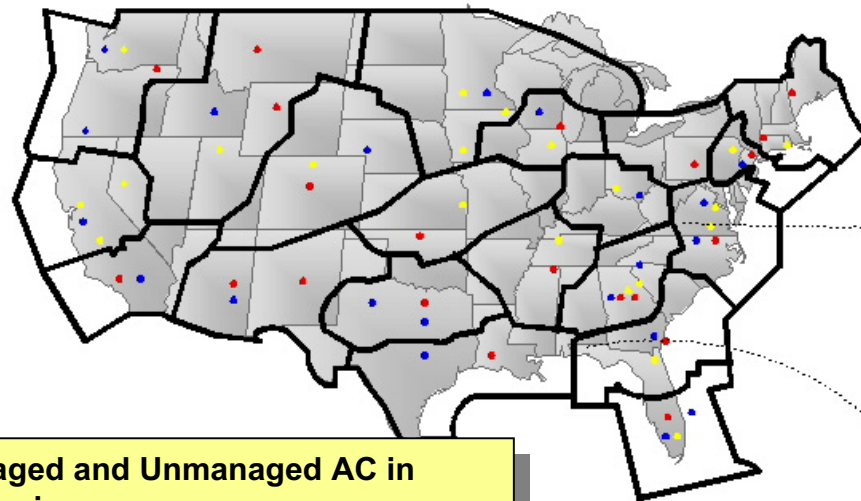
VAST Organization Chart

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VAST Development Approach

Airspace Modeling and Simulation

- **Develop the architecture for the Airspace Concept Evaluation System**

- **Develop models to support ATM system assessments through simulation and analysis**
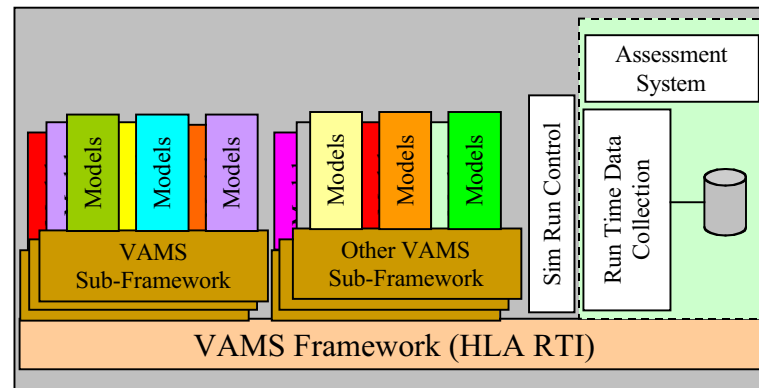
- **Transfer appropriate models and technology for application within the real-time simulation environment**

Prototype Simulation Description

NAS- Wide Enroute Simulation

Interwoven agent interactions:
- different Airlines / different strategies
- controller interactions with AC

ZTL

Managed and Unmanaged AC in same airspace

Different CD&R for Unmanaged AC

Unmanaged Aircraft

Managed Aircraft

Red - Airline #1 (All Managed)

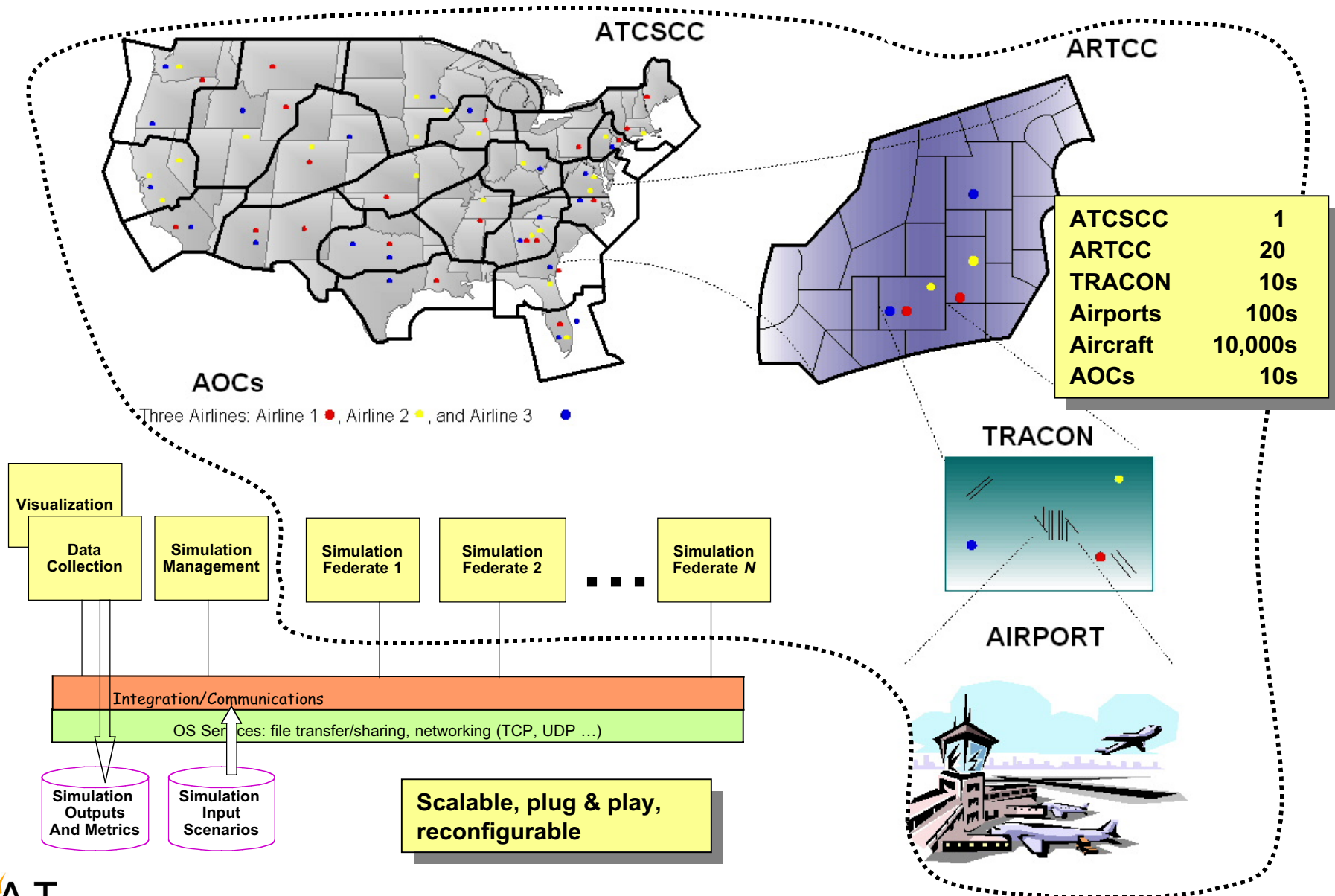**Blue** - Airline #2 (All Unmanaged)
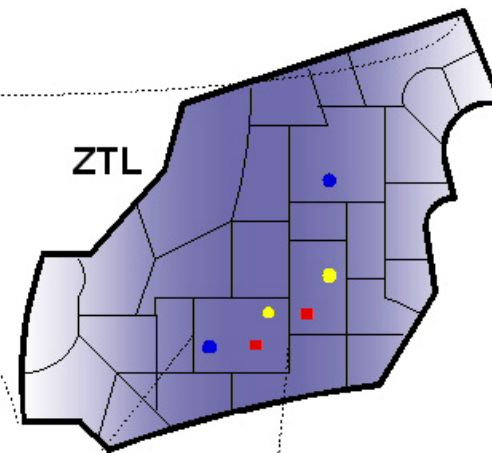
- **Airline federate schedules**
  - Airline #1 with a fleet of 500 unmanaged aircraft
  - Airline #2 with a fleet of 500 managed aircraft
  - Flight schedules generated using a "random flight scheduler" based on ETMS data
- **En Route federate**
  - Simulates En Route NAS, modeling geometry, infrastructure, and various NAS dynamic and static agents at low fidelity (Pilots, AOCs, ATCSCC, ARTCC, Controllers, NAS geometry, etc.) as these airlines fly across the NAS
- **Controller federate**
  - Simulates ZNY56, ZDC04, ZDC12
- **Simulation Manager controls the simulation**
- **Data Collection federate**
  - Fuel, conflicts, near misses logged to a database

Airspace Concept Evaluation System
Build-1 Development

- **Emphasizes establishment of the core architectural foundation that is designed for flexibility, scalability and extensibility**

- **Expands the initial set of models within the toolbox**

  – Enables study of benefits from candidate improvements such as ATC and flight deck enhancements

  – Enables evaluation of the effect of increased future traffic demand

  – Precludes study of radical system improvements such as aggressive implementation of free flight

- **Focuses on run-time capability versus efficiency**

- **Integrates / develops basic simulation control, data collection and visualization**
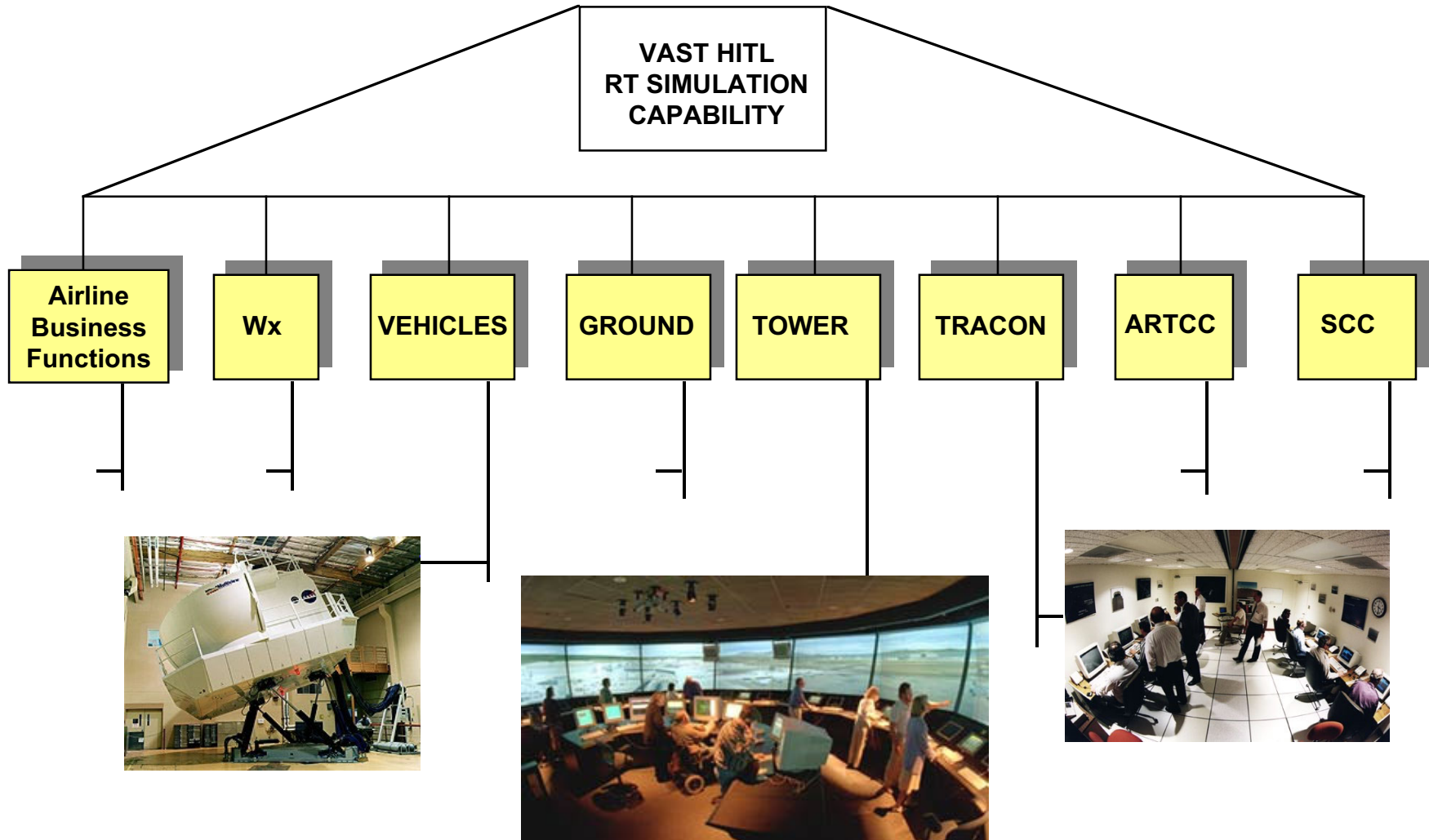
Build-1 Simulation Description

ATCSCC

ARTCC

AOCs

Three Airlines: Airline 1 ●, Airline 2 ●, and Airline 3 ●

ATCSCC	1
ARTCC	20
TRACON	10s
Airports	100s
Aircraft	10,000s
AOCs	10s

TRACON

AIRPORT

Visualization

Data Collection

Simulation Management

Simulation Federate 1

Simulation Federate 2

· · ·

Simulation Federate *N*

Integration/Communications

OS Services: file transfer/sharing, networking (TCP, UDP …)

Simulation Outputs And Metrics

Simulation Input Scenarios

Scalable, plug & play, reconfigurable

AS

AT

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- **Demonstrated a <u>proof-of-concept</u> prototype**
  - Selected the DoD's HLA-RTI infrastructure with agent-based software to enable fast-time NAS-wide simulation
  - Established a modeling lab that leverages existing and emerging models and tools

- **<u>Proving the feasibility</u> of the approach to capture the interactions between NAS entities (Build-1)**
  - Integrate a suite of low-medium fidelity NAS models
  - Model dynamic effects of interactive agents
  - Assess NAS operational performance

- **<u>Enhancing the modeling</u> toolbox by adding NAS functionality**
  - Develop and validate new models of NAS components
  - Increase model fidelity and simulation speed

- **Defining requirements for usability to enable <u>technology transfer</u> to airspace analysts**

Real-Time Human-In-The-Loop Simulation

- **Design a distributed network capability that integrates ATM simulator facilities, labs and real-time software models to support assessments of human interactions with airspace concepts and technologies**
  - Define real-time environments and establish preliminary design
  - Complete requirements and initial design

- **Develop initial capability and validate against a defined operational concept**
  - Adapt models developed within the Airspace Modeling and Simulation Task for use in real-time simulation
  - Develop models unique to real-time simulation
  - Develop interface requirements to simulators and labs

- **Enhance capability to include multi-facility functionality**
  - Establish infrastructure to conduct multi-facility simulations

- **Complete capability to support concept development**

Real-Time Concept

VAST HITL RT SIMULATION CAPABILITY

- Airline Business Functions
- Wx
- VEHICLES
- GROUND
- TOWER
- TRACON
- ARTCC
- SCC

Human/Team Performance Modeling

- **Develop and validate human and team models that predict operator performance within VAMS operational concepts**

  - Define and model cognitive demands of supervisory control in highly-automated human-machine systems

  - Define and model individual and team decision strategies

  - Define and model performance characteristics of mixed-initiative systems

- **Develop rapid re-configurable airspace operator models for new concepts**

  - Software architecture: interoperable, portable, versatile, scalable, extensible

  - Usability: high-level modeling language, model debugging support, and data visualization tools

  - Model building blocks: templates for human-computer interaction, and libraries of reusable physical environment widgets

  - Integrate Human/Team Performance models into Build 3 of modeling toolbox
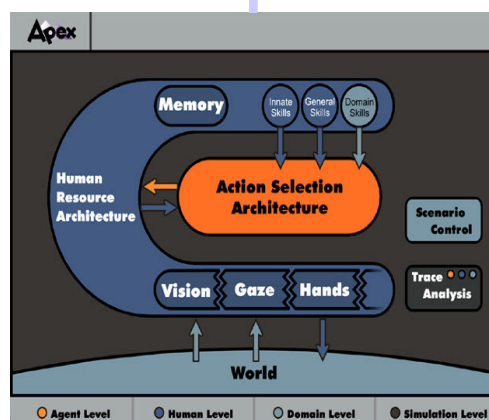
Human/Team Performance Modeling

Concept Simulations
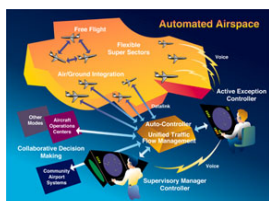
Human Factors Evaluations

Real-Time Simulation Suite

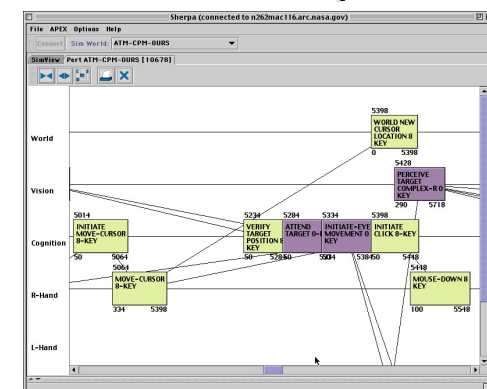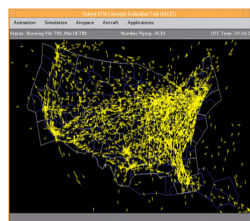*Fast-Time Simulation Toolkit*

Model Support Tools

Modeler API
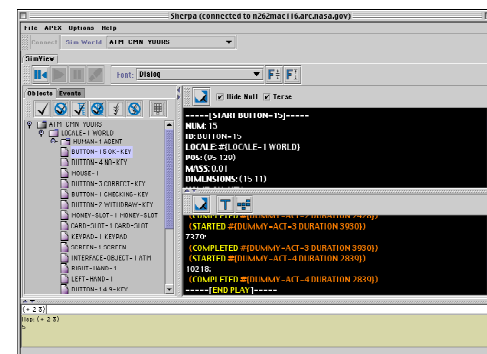
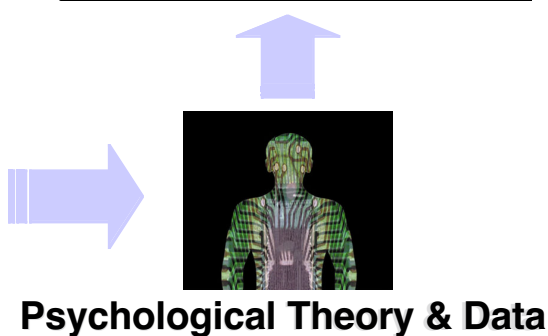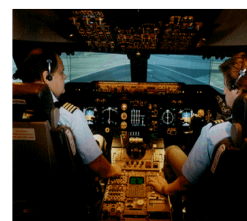**Behavioral Templates**

Simulated Human Agent

Situation Assessment

Distributed Decision Making

Communication
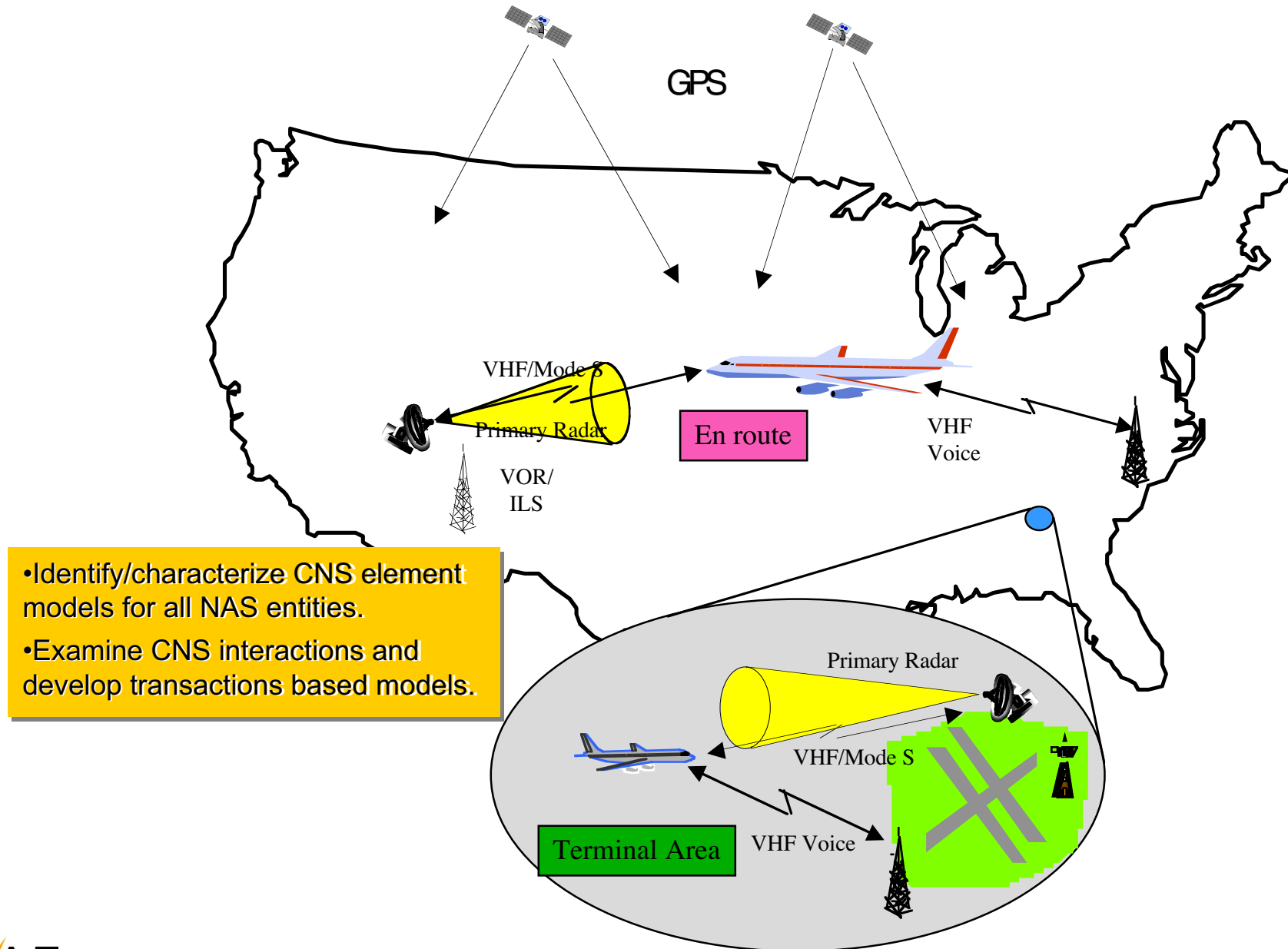
Operator Task Demands
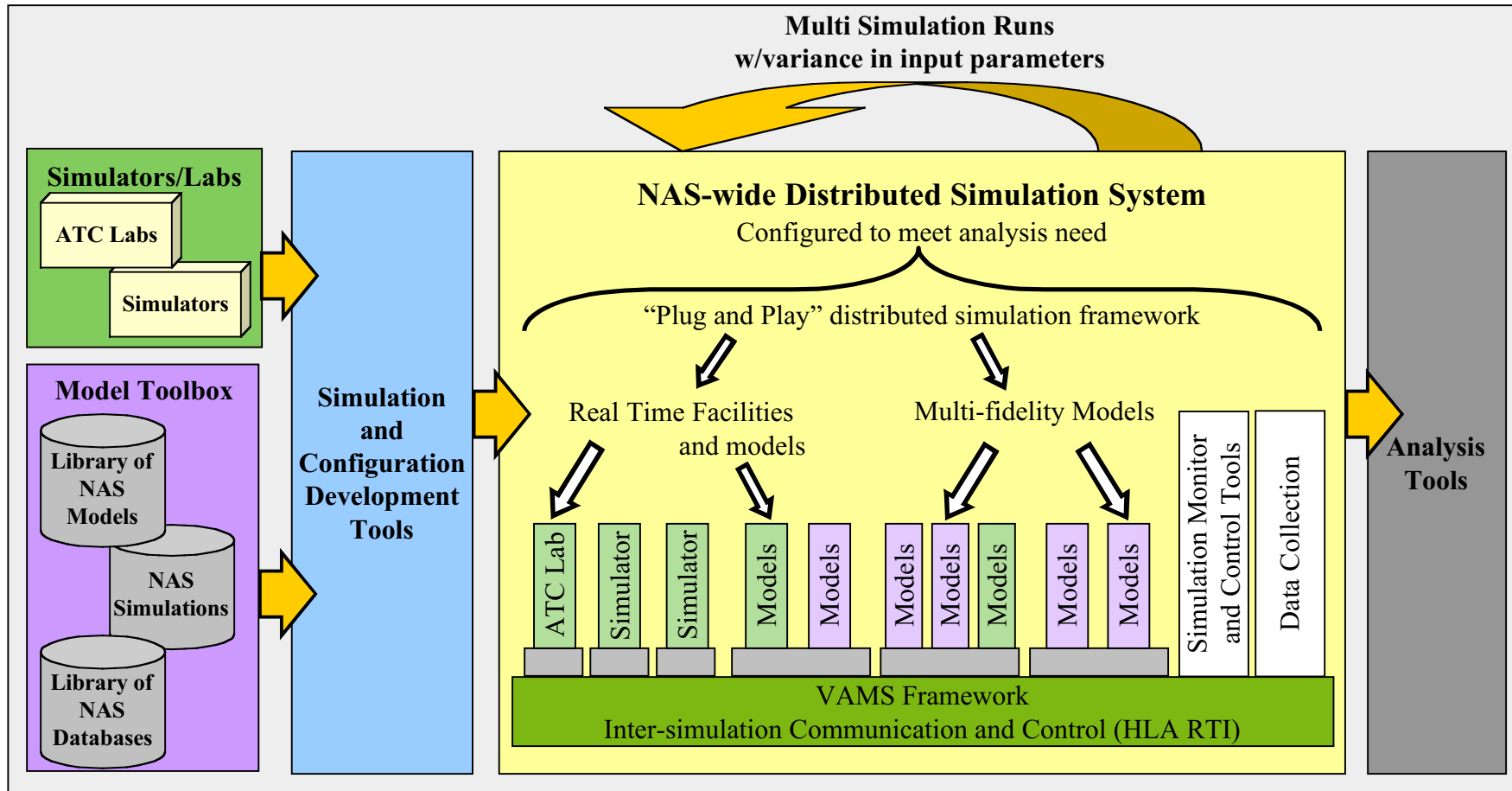
Psychological Theory & Data

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CNS Modeling

- **Develop requirements for CNS modeling that supports evaluation of VAMS operational concepts**

  – Identify and categorize CNS modeling and simulation capabilities and needs

  – Identify approach to CNS model and CNS infrastructure assessment

- **Develop communication, navigation and surveillance models for today's system, technologies currently being considered within the FAA's OEP, and technologies being considered for the future**

  – Develop and demonstrate standard communications traffic model for assessing CNS model elements and architectures

  – Integrate CNS modeling activities into Build 3 of modeling toolbox

CNS Simulation Description

GPS

VHF/Mode S

Primary Radar

VOR/ILS

En route

VHF Voice

•Identify/characterize CNS element models for all NAS entities.

•Examine CNS interactions and develop transactions based models.

Primary Radar

VHF/Mode S

Terminal Area

VHF Voice

Virtual Airspace Simulation Environment Concept

VAST Interdependencies

Socio-Econ/Demographic Project Office

Concepts
Transition
UCIC

SLIC

Concept results
Requirements
Priorities

Testing/Eval.
Capabilities
• guidelines
• metrics
• CSS

SEA

Common Scenario Set (CSS)
- Evaluation Criteria
- Metrics
- Methods
- Experimental Plan (EP)

Recommend Priorities
Concept results
Comments

Requirements
(Continuous)
Exp. Plan

Requirements
Feedback
Tool Capabilities

VAST

Requirements
Feedback
Tool Capabilities

ACES
RT-HITL

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VAST Challenges

- **VAST's overarching measure of success is to produce analytical models and analysis results that enable the implementation of new ATM technologies and concepts**

- **Technical Challenges**
  - Identifying and prioritizing a set of existing models
  - Developing models to fill gaps
  - Integrating and validating the set of models and methods
  - Integrating with human-in-the-loop simulations and validating those methods

- **Process Challenges**
  - Fostering a cooperative environment and proposing standards within the ATM modeling and simulation community
  - Providing verified and validated simulation testbeds that represent the air transportation system
  - Advancing the fundamental understanding of the dynamic interactions within the NAS
  - Making the tools accessible to users

Summary

- **VAST seeks to produce new national capabilities to assess airspace concepts at the system-level and detailed human-in-the-loop level**
  - Architectures that are scalable, extendable and re-configurable, and support distributed simulation in non-real-time and real-time domains
  - Toolbox of agent-based models to select from and build simulations
  - Facility interface standards
  - Simulation and assessment tools and utilities

- **VAST success requires a cooperative effort**
  - Concept developers
  - Concept evaluators
  - Modeling and simulation developers

- **Efforts within VAST are underway and progressing well toward early project milestones**

- **VAST Focused TIM #2**